

WHAT IS CLAIMED IS:

1. A semiconductor device comprising a semiconductor film having a crystal structure, provided on an insulating surface,

5 wherein a concentration of oxygen contained in the semiconductor film is equal to or less than $5 \times 10^{18}/\text{cm}^3$, and

wherein an area comprising a rare gas element at a concentration of 1×10^{13} to $1 \times 10^{20}/\text{cm}^3$ exists inside the semiconductor film or in the vicinity of a surface of the semiconductor film.

10 2. A semiconductor device according to claim 1, wherein the rare gas element is at least one selected from the group consisting of He, Ne, Ar, Kr, and Xe.

15 3. A semiconductor device, comprising a semiconductor film having a crystal structure, provided on an insulating surface,

wherein the semiconductor film is a crystal having a narrow bar shape or a narrow and flat bar shape,

wherein a concentration of oxygen contained in the semiconductor film is equal to or less than $5 \times 10^{18}/\text{cm}^3$, and

20 wherein an area comprising a rare gas element at a concentration of 1×10^{13} to $1 \times 10^{20}/\text{cm}^3$ exists inside the semiconductor film or in the vicinity of a surface of the semiconductor film.

25 4. A semiconductor device according to claim 3, wherein the rare gas element is at least one selected from the group consisting of He, Ne, Ar, Kr, and Xe.

5. A semiconductor device comprising:

a semiconductor film having a crystal structure, provided on an insulating surface;

30 a gate insulating film; and

a gate electrode,

wherein the semiconductor film comprises oxygen at a concentration equal to or less than $5 \times 10^{18}/\text{cm}^3$ in a region overlapping the gate electrode, and

wherein an area comprising a rare gas element at a concentration of 1×10^{13} to $1 \times 10^{20}/\text{cm}^3$ exists inside the semiconductor film or in the vicinity of an interface with the gate insulating film.

6. A semiconductor device according to claim 5, wherein the rare gas element is at least one selected from the group consisting of He, Ne, Ar, Kr, and Xe.

7. A semiconductor device comprising:

a semiconductor film having a crystal structure, provided on an insulating surface;

a gate insulating film; and

a gate electrode,

wherein the semiconductor film is a crystal having a narrow bar shape or a narrow and flat bar shape,

wherein the semiconductor film comprises oxygen at a concentration equal to or less than $5 \times 10^{18}/\text{cm}^3$ in a region overlapping the gate electrode, and

wherein an area comprising a rare gas element at a concentration of 1×10^{13} to $1 \times 10^{20}/\text{cm}^3$ exists inside the semiconductor film or in the vicinity of an interface with the gate insulating film.

8. A semiconductor device according to claim 7, wherein the rare gas element is at least one selected from the group consisting of He, Ne, Ar, Kr, and Xe.

9. A method of manufacturing a semiconductor device comprising:

forming a first semiconductor film comprising an amorphous silicon over a substrate having an insulating surface;

adding a material comprising a metal for promoting crystallization to the first

semiconductor film;

performing a first heating process to the first semiconductor film, thereby forming the first semiconductor film having a crystal structure;

forming a barrier layer on a surface of the first semiconductor film having the
5 crystal structure;

forming a second semiconductor film containing a rare gas element on the barrier layer;

performing gettering through a second heating process, thereby moving the catalytic element to the second semiconductor film; and

10 removing the second semiconductor film.

10. A method of manufacturing a semiconductor device according to claim 9, wherein the rare gas element is added simultaneously with the formation of the second semiconductor film.

15 11. A method of manufacturing a semiconductor device according to claim 9, wherein the rare gas element is added after the formation of the second semiconductor film.

12. A method of manufacturing a semiconductor device according to claim 9,
20 wherein the barrier layer is formed from a chemical oxide film that is formed using ozone water.

13. A method of manufacturing a semiconductor device according to claim 9, wherein the barrier layer is formed by oxidizing a surface of the barrier layer through a
25 plasma process.

14. A method of manufacturing a semiconductor device according to claim 9, wherein the barrier layer is formed by oxidizing a surface of the barrier layer by generating ozone through irradiation with ultraviolet rays in an oxygen containing atmosphere.

30

15. A method of manufacturing a semiconductor device according to claim 9, wherein the rare gas element is at least one selected from the group consisting of He, Ne, Ar, Kr, and Xe.

5 16. A method of manufacturing a semiconductor device according to claim 9, wherein the rare gas element is added using one of an ion implantation method and an ion doping method.

10 17. A method of manufacturing a semiconductor device according to claim 9, wherein the first heating process is performed by radiation from a light source, the light source comprising at least one selected from the group consisting of a halogen lamp, a metal halide lamp, a xenon arc lamp, a carbon arc lamp, a high pressure sodium lamp, and a high pressure mercury lamp.

15 18. A method of manufacturing a semiconductor device according to claim 9, wherein the first heating process is performed with a furnace annealing method that uses an electric heating furnace.

20 19. A method of manufacturing a semiconductor device according to claim 9, wherein the second heating process is performed by radiation from a light source, the light source comprising at least one selected from the group consisting of a halogen lamp, a metal halide lamp, a xenon arc lamp, a carbon arc lamp, a high pressure sodium lamp, and a high pressure mercury lamp.

25 20. A method of manufacturing a semiconductor device according to claim 9, wherein the second heating process is performed with a furnace annealing method that uses an electric heating furnace.

30 21. A method of manufacturing a semiconductor device according to claim 9, wherein the catalytic element is at least one selected from the group consisting of Fe, Ni,

Co, Ru, Rh, Pd, Os, Ir, Pt, Cu, and Au.

22. A method for manufacturing a semiconductor device according to claim 9,
wherein the second semiconductor film is formed using one of a plasma CVD method and
5 high-frequency sputtering method.

23. A method of manufacturing a semiconductor device comprising:

forming a first semiconductor film comprising an amorphous silicon over a
substrate having an insulating surface;

10 adding a material comprising a metal for promoting crystallization to the first
semiconductor film;

performing a first heating process to the first semiconductor film, thereby
forming the first semiconductor film having a crystal structure;

15 irradiating the first semiconductor film having the crystal structure with laser
light;

forming a barrier layer on a surface of the first semiconductor film having the
crystal structure;

forming a second semiconductor film containing rare gas element on the
barrier layer;

20 performing gettering through a second heating process, thereby moving the
catalytic element to the second semiconductor film; and

removing the second semiconductor film.

24. A method of manufacturing a semiconductor device according to claim 23,
25 wherein the rare gas element is added simultaneously with the formation of the second
semiconductor film.

25. A method of manufacturing a semiconductor device according to claim 23,
wherein the rare gas element is added after the formation of the second semiconductor film.

30

26. A method of manufacturing a semiconductor device according to claim 23, wherein the barrier layer is formed from a chemical oxide film that is formed using ozone water.

5 27. A method of manufacturing a semiconductor device according to claim 23, wherein the barrier layer is formed by oxidizing a surface of the barrier layer through a plasma process.

10 28. A method of manufacturing a semiconductor device according to claim 23, wherein the barrier layer is formed by oxidizing a surface of the barrier layer by generating ozone through irradiation with ultraviolet rays in an oxygen containing atmosphere.

15 29. A method of manufacturing a semiconductor device according to claim 23, wherein the rare gas element is at least one selected from the group consisting of He, Ne, Ar, Kr, and Xe.

20 30. A method of manufacturing a semiconductor device according to claim 23, wherein the rare gas element is added using one of an ion implantation method and an ion doping method.

25 31. A method of manufacturing a semiconductor device according to claim 23, wherein the first heating process is performed by radiation from a light source, the light source comprising at least one selected from the group consisting of a halogen lamp, a metal halide lamp, a xenon arc lamp, a carbon arc lamp, a high pressure sodium lamp, and a high pressure mercury lamp.

30 32. A method of manufacturing a semiconductor device according to claim 23, wherein the first heating process is performed with a furnace annealing method that uses an electric heating furnace.

33. A method of manufacturing a semiconductor device according to claim 23, wherein the second heating process is performed by radiation from a light source, the light source comprising at least one selected from the group consisting of a halogen lamp, a metal halide lamp, a xenon arc lamp, a carbon arc lamp, a high pressure sodium lamp, and a high pressure mercury lamp.

34. A method of manufacturing a semiconductor device according to claim 23, wherein the second heating process is performed with a furnace annealing method that uses an electric heating furnace.

35. A method of manufacturing a semiconductor device according to claim 23, wherein the catalytic element is at least one selected from the group consisting of Fe, Ni, Co, Ru, Rh, Pd, Os, Ir, Pt, Cu, and Au.

36. A method for manufacturing a semiconductor device according to claim 23, wherein the second semiconductor film is formed using one of a plasma CVD method and a high-frequency sputtering method.

37. A method of manufacturing a semiconductor device comprising:

forming a first semiconductor film comprising an amorphous silicon over a substrate having an insulating surface;

adding a material comprising a metal for promoting crystallization to the first semiconductor film;

performing a first heating process to the first semiconductor film, thereby

forming the first semiconductor film having a crystal structure;

forming a barrier layer on a surface of the first semiconductor film having the crystal structure;

forming a second semiconductor film containing a rare gas element on the barrier layer;

performing gettering through a second heating process, thereby moving the

catalytic element to the second semiconductor film;
removing the second semiconductor film; and
irradiating the first semiconductor film having the crystal structure with laser
light.

5

38. A method of manufacturing a semiconductor device according to claim 37,
wherein the rare gas element is added simultaneously with the formation of the second
semiconductor film.

10

39. A method of manufacturing a semiconductor device according to claim 37,
wherein the rare gas element is added after the formation of the second semiconductor film.

15

40. A method of manufacturing a semiconductor device according to claim 37,
wherein the barrier layer is formed from a chemical oxide film that is formed using ozone
water.

20

41. A method of manufacturing a semiconductor device according to claim 37,
wherein the barrier layer is formed by oxidizing a surface of the barrier layer through a
plasma process.

25

42. A method of manufacturing a semiconductor device according to claim 37,
wherein the barrier layer is formed by oxidizing a surface of the barrier layer by generating
ozone through irradiation with ultraviolet rays in an oxygen containing atmosphere.

43. A method of manufacturing a semiconductor device according to claim 37,
wherein the rare gas element is at least one selected from the group consisting of He, Ne,
Ar, Kr, and Xe.

30

44. A method of manufacturing a semiconductor device according to claim 37,
wherein the rare gas element is added using one of an ion implantation method and an ion

doping method.

45. A method of manufacturing a semiconductor device according to claim 37, wherein the first heating process is performed by radiation from a light source, the light source comprising at least one selected from the group consisting of a halogen lamp, a metal halide lamp, a xenon arc lamp, a carbon arc lamp, a high pressure sodium lamp, and a high pressure mercury lamp.

46. A method of manufacturing a semiconductor device according to claim 37, wherein the first heating process is performed with a furnace annealing method that uses an electric heating furnace.

47. A method of manufacturing a semiconductor device according to claim 37, wherein the second heating process is performed by radiation from a light source, the light source comprising at least one selected from the group consisting of a halogen lamp, a metal halide lamp, a xenon arc lamp, a carbon arc lamp, a high pressure sodium lamp, and a high pressure mercury lamp.

48. A method of manufacturing a semiconductor device according to claim 37, wherein the second heating process is performed with a furnace annealing method that uses an electric heating furnace.

49. A method of manufacturing a semiconductor device according to claim 37, wherein the catalytic element is at least one selected from the group consisting of Fe, Ni, Co, Ru, Rh, Pd, Os, Ir, Pt, Cu, and Au.

50. A method for manufacturing a semiconductor device according to claim 37, wherein the second semiconductor film is formed by a plasma CVD method and a high-frequency sputtering method.

51. A method of manufacturing a semiconductor device comprising:

forming a first amorphous semiconductor film comprising silicon over a substrate having an insulating surface;

5 adding a material comprising a metal for promoting crystallization to the first semiconductor layer having the amorphous structure;

forming a barrier layer on a surface of the first amorphous semiconductor film;

forming a second semiconductor film containing a rare gas element on the barrier layer;

10 forming the first crystallized semiconductor film by crystallizing the first amorphous semiconductor film and moving the catalytic element to the second semiconductor film, through a heating process;

removing the second semiconductor film; and

irradiating the first crystallized semiconductor film with laser light.

15 52. A method of manufacturing a semiconductor device according to claim 51, wherein the rare gas element is added simultaneously with the formation of the second semiconductor film.

20 53. A method of manufacturing a semiconductor device according to claim 51, wherein the rare gas element is added after the formation of the second semiconductor film.

25 54. A method of manufacturing a semiconductor device according to claim 51, wherein the barrier layer is formed from a chemical oxide film that is formed using ozone water.

55. A method of manufacturing a semiconductor device according to claim 51, wherein the barrier layer is formed by oxidizing a surface of the barrier layer through a plasma process.

30 56. A method of manufacturing a semiconductor device according to claim 51,

wherein the barrier layer is formed by oxidizing a surface of the barrier layer by generating ozone through irradiation with ultraviolet rays in an oxygen containing atmosphere.

57. A method of manufacturing a semiconductor device according to claim 51,
5 wherein the rare gas element is at least one selected from the group consisting of He, Ne, Ar, Kr, and Xe.

58. A method of manufacturing a semiconductor device according to claim 51,
wherein the rare gas element is added using one of an ion implantation method and an ion
10 doping method.

59. A method of manufacturing a semiconductor device according to claim 51,
wherein the heating process is performed by radiation from a light source, the light source
comprising at least one selected from the group consisting of a halogen lamp, a metal
15 halide lamp, a xenon arc lamp, a carbon arc lamp, a high pressure sodium lamp, and a high pressure mercury lamp.

60. A method of manufacturing a semiconductor device according to claim 51,
wherein the heating process is performed with a furnace annealing method that uses an
20 electric heating furnace.

61. A method of manufacturing a semiconductor device according to claim 51,
wherein the catalytic element is at least one selected from the group consisting of Fe, Ni,
Co, Ru, Rh, Pd, Os, Ir, Pt, Cu, and Au.

62. A method for manufacturing a semiconductor device according to claim 51,
wherein the second semiconductor film is formed by a plasma CVD method and a high-
frequency sputtering method.

63. A method of manufacturing a semiconductor device comprising:

adding a material comprising a metal for promoting crystallization over a substrate having the insulating surface;

forming a first amorphous semiconductor film comprising silicon on the substrate;

5 forming a barrier layer on a surface of the first amorphous semiconductor film;

forming a second semiconductor film containing a rare gas element on the first amorphous semiconductor film;

forming the first crystallized semiconductor film by crystallizing the first amorphous semiconductor film and moving the catalytic element to the second

10 semiconductor film, through a heating process;

removing the second semiconductor film; and

irradiating the first crystallized semiconductor film with laser light.

64. A method of manufacturing a semiconductor device according to claim 63,
15 wherein the rare gas element is added simultaneously with the formation of the second semiconductor film.

65. A method of manufacturing a semiconductor device according to claim 63,
wherein the rare gas element is added after the formation of the second semiconductor film.

20 66. A method of manufacturing a semiconductor device according to claim 63,
wherein the barrier layer is formed from a chemical oxide film that is formed using ozone water.

25 67. A method of manufacturing a semiconductor device according to claim 63,
wherein the barrier layer is formed by oxidizing a surface of the barrier layer through a plasma process.

68. A method of manufacturing a semiconductor device according to claim 63,
30 wherein the barrier layer is formed by oxidizing a surface of the barrier layer by generating

ozone through irradiation with ultraviolet rays in an oxygen containing atmosphere.

69. A method of manufacturing a semiconductor device according to claim 63, wherein the rare gas element is at least one selected from the group consisting of He, Ne,
5 Ar, Kr, and Xe.

70. A method of manufacturing a semiconductor device according to claim 63, wherein the rare gas element is added using one of an ion implantation method and an ion doping method.

10 71. A method of manufacturing a semiconductor device according to claim 63, wherein the heating process is performed by radiation from a light source, the light source comprising at least one selected from the group consisting of a halogen lamp, a metal halide lamp, a xenon arc lamp, a carbon arc lamp, a high pressure sodium lamp, and a high
15 pressure mercury lamp.

72. A method of manufacturing a semiconductor device according to claim 63, wherein the heating process is performed with a furnace annealing method that uses an electric heating furnace.

20 73. A method of manufacturing a semiconductor device according to claim 63, wherein the catalytic element is at least one selected from the group consisting of Fe, Ni, Co, Ru, Rh, Pd, Os, Ir, Pt, Cu, and Au.

25 74. A method for manufacturing a semiconductor device according to claim 63, wherein the second semiconductor film is formed by a plasma CVD method and a high-frequency sputtering method.

75. A method of manufacturing a semiconductor device comprising:
30 providing a semiconductor film comprising amorphous silicon with a metal

containing material for promoting crystallization;

heating the semiconductor film and the metal to crystallize the semiconductor film;

irradiating the crystallized semiconductor film with light so that the
5 crystallized semiconductor film is melted at least partly; and

removing the metal from the crystallized semiconductor film by gettering after the irradiation of the light.

76. The method according to claim 75 wherein said light is laser light.

77. The method according to claim 75 wherein said light has an energy density
of 360 mJ/cm² or higher.

78. A method of manufacturing a semiconductor device comprising:
15 providing a semiconductor film comprising amorphous silicon with a metal containing material for promoting crystallization;

heating the semiconductor film and the metal to crystallize the semiconductor film wherein a first metal silicide is segregated at a grain boundary of the crystallized semiconductor film;

20 irradiating the crystallized semiconductor film with light in order that a second metal silicide is segregated at the grain boundary wherein the second metal silicide is more unstable than the first metal silicide; and

removing the metal from the crystallized semiconductor film by gettering after the irradiation of the light.

79. The method according to claim 78 wherein said light is laser light.

80. The method according to claim 78 wherein said light has an energy density
of 360 mJ/cm² or higher.